SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 SCOPE

As detailed in Section 1, this report covers the waste generated from the extraction and beneficiation (concentration) of metallic ores, phosphates, and asbestos and the mining of uranium. Although these selected mining segments include only about five percent of the 13,000 active mining operations in the U.S. noncoal mining industry, the facilities covered in this report generate over 90 percent of the total waste material produced by all noncoal mines.

6.2 SUMMARY OF CONCLUSIONS

The Agency's conclusions from the studies presented in this report are summarized under major groupings paralleling the organization of the report, namely: (1) Structure and Location of Mines, (2) Waste Quantities, (3) Potential Hazard Characteristics, (4) Evidence of Environmental Transport, (5) Evidence of Damage, (6) Management Practices, and (7) Potential Costs of Regulation.

6.2.1 Structure and Location of Mines

Because of the wide availability of detailed and comprehensive information published by the U.S. Bureau of Mines and supplemented by data from industry trade associations, EPA's conclusions on the numbers, sizes, and locations of U.S. mines are based solely on these standard sources.

1. There is a relatively small number of mines in the segments under consideration in this study. Fewer than 500 mine sites (1985)

extract and concentrate metals, phosphates, and asbestos in the U.S. (excluding gold placer mines). Of these, about 290 (62 percent) are accounted for by the precious metals (gold, silver) and uranium segments alone.

2. There is a great diversity in the size of mining facilities. This is true whether one measures size in terms of property area, product tonnage, total volume of material handled, or waste generated. The largest mine sites (e.g., in the iron ore, copper, and phosphate segments) are measured in terms of square kilometers, and each one handles more than 10 million tons of material per year. By contrast, about 25 percent of the mines included in this study handle less than 1,000 tons per year.
3. There is also great diversity in the unit value of product mined. In the segments studied, this value varies from $20 per ton for crude phosphate to over $10 million per ton for gold.
4. With few exceptions (notably in the precious metals) the trend has been toward a reduction in the number of active mines in most segments and an increase in the number of inactive mines, closed or abandoned mines.
5. Metals, phosphate, and asbestos mining are very heavily concentrated in a few States and EPA Regions. Over 90 percent of the mine sites in the industry segments are west of the Mississippi River, and over 60 percent are concentrated in just 10 States with 20 or more mines each. Eight of these 10 States are in the Rocky Mountain and Great Basin regions (EPA Regions 6,8,9, and 10), where almost 65 percent of U.S. metal mines are located.

6. <u>These mines are generally located in areas of low population density. They are often, although not always, located several kilometers from population centers and the sources of public water supplies (reduced human exposure impact).</u>

6.2.2 <u>Waste Quantities</u>

The conclusions summarized in this section are derived primarily from EPA studies. Waste quantity estimates are based largely on primary data from the U.S. Bureau of Mines on ore concentration and productivity for individual mine properties or producing regions, supplemented by EPA-sponsored engineering studies and extrapolations. These studies and extrapolations are described in detail in Section 4.1 and Appendix B to this report. Waste types and quantities reported here include all mine overburden and waste rock (mine waste), material subject to dump (copper) or heap (gold and silver) leach operations, and tailings from beneficiation processes.

1. <u>Annual aggregate waste quantities for these segments are large by any standard.</u> Mines in the metal, phosphate, and asbestos segments produce about 1.0 to 1.3 billion metric tons per year of various types of mining waste. By contrast, total municipal "post-consumer" solid waste totals 150 million tons and total industrial hazardous waste for all industries other than mining totals about 250 million tons per year.
2. <u>Total waste accumulated by all active, inactive, and abandoned mines since 1910 is estimated at 50 billion metric tons.</u>
3. <u>Ratios of waste to product in mining vary considerably, but are generally substantially higher than for any other industries.</u> The percentage of marketable ore obtained from mining operations ranges from 60 percent of the material excavated at iron ore mines to

30 percent at surface copper mines and 7 percent at surface uranium mines. By contrast, 50 percent or more of all the harvested wood in the forest products industry becomes marketed wood or paper products, and only a very small percentage of crude oil remains as waste in the production of fuels and petrochemicals.

4. Total waste quantities vary greatly among facilities in mining. As noted earlier, 25 percent of the mines in this study are rated at less than 1,000 tons per year of total material handled (well within the waste generation range of facilities in, say, the pulp and paper or petrochemicals industries.) On the other hand, the larger facilities in the copper, iron, and phosphate mining segments handle more than 10 million tons per year each. Any one of these larger individual facilities will generate more total waste in the normal course of its activities than all firms together in almost any other industry.

5. Aggregate waste in mining is concentrated in a few segments and a few states. Seventy percent of the 1.3 billion tons of total mining waste (1982) was generated in two segments, copper (39 percent) and phosphates (31 percent). This suggests that almost 23 percent of all mining waste is generated in Arizona (68 percent of copper production), and that almost 23 percent of this waste is generated in Florida (74 percent of U.S. phosphate production). An additional 14 percent of all mining waste was contributed by iron mining (largely in Minnesota), and 6 percent by uranium (Colorado, New Mexico, Utah, and Wyoming). All remaining nonfuel mining segments together generated the remaining 10 percent of total mining industry waste.

6.2.3 Potential Hazard Characteristics

Data on waste hazard characteristics are the result of extensive EPA sampling and analysis studies, as described in Section 4, and are based on samples from 86 extraction and beneficiation sites.

1. Of the 1.3 billion metric tons of waste produced each year, only 61 million metric tons (5 percent) of copper, gold, silver, lead, or zinc wastes exhibited RCRA hazardous characteristics. These include 50 million metric tons of corrosive (pH less than 2.0) copper leach dump waste and 11 million metric tons of gold, silver, lead, or zinc overburden or tailings that were EP toxic (generally for lead). EP toxicity test leachates from gold, silver, lead, zinc, uranium, and other metal wastes had toxic metal concentrations between 20 and 100 times the levels set by the National Interim Primary Drinking Water Standards; however, these were below the threshold of being a hazardous waste.
2. Twenty-three million metric tons per year of gold and silver wastes are potentially hazardous because they have been leached using a cyanide solution. These cyanide wastes include those metal recovery wastes previously listed as hazardous, as well as heap leaching wastes, but do not include copper mill tailings or other mill tailings with low (less than 10 mg/liter) concentrations of cyanide from flotation circuits.
3. Copper leach dump material (182 MMT) and copper mill tailings (95 MMT) may be hazardous. In addition to the 50 MMT/year of copper leach dump waste estimated to be corrosive, the remaining 132 MMT of this waste may also pose potential hazards because of its low pH and relatively high concentrations of toxic metals. Copper leach dump

wastes are potentially hazardous even when the pH level of their leachate is not below 2.0, because their leachate is still quite acidic and contains toxic metals. However, toxic constituents in and hazardous characteristics of these wastes do not exceed EPA's established criteria. Similarly, copper, gold, silver, and lead mill tailings containing high (greater than 1 percent) concentrations of pyritic material and low (less than 1 percent) concentrations of carbonate buffers have a high potential for forming and releasing sulfuric acid.

4. <u>Naturally occurring radioactivity (radium-226) levels in excess of five picocuries per gram (pCi/g) has been estimated for 443 million metric tons/year of wastes from sites generating uranium mine waste and phosphate wastes.</u> Use of an alternative radioactivity measure of 20 pCi/g yields an aggregate estimate of about 93 million metric tons/year of radioactive waste, most of which is uranium mine waste.

5. <u>Four asbestos mines generate about 5 million metric tons per year of waste containing high (greater than 1 percent) asbestos fiber content.</u> Only asbestos mines were tested in the current study for asbestos fibers.

6. <u>EPA's solid waste sampling thus far has not found any hazardous characteristic in waste from the iron ore, molybdenum, or certain minor metals segments.</u> The Agency tested wastes from virtually all metal mining segments but did not test wastes from all mineral mining segments, on the assumption that these wastes are unlikely to be hazardous.

7. <u>Based on the above, the Agency concludes that as many as 80 percent of the metal mining facilities and perhaps 56 percent of the waste</u>

generated could be considered potentially hazardous to human health or the environment under some circumstances. Generally, a given mine site will exhibit only one primary problem: EP toxicity, cyanide contamination, corrosivity/acidity, radioactivity, or asbestos, according to the Agency's sampling results.

6.2.4 Evidence of Environmental Transport of Potentially Hazardous Constituents

The potentially hazardous constituents and characteristics of various mining wastes can be transported from the location of storage or disposal to possible receptors by various combinations of surface water flow, seepage into ground water and ground-water flow, and wind currents. The Agency's studies in this area focused primarily on efforts to evaluate environmental transfer to and through surface and ground water. Study methods included both a literature search and a limited field monitoring study at eight selected mine sites (one only for surface water) over a 6- to 9-month monitoring period.

1. Ground-water monitoring is difficult, expensive, and has seldom been conducted at mine sites on a comprehensive basis. Because of complex geologic strata (presence of an ore body) and the extensive size of many mine properties, proper ground-water monitoring is technically difficult and costly. Historical practice in the mining industry has not required such monitoring. As a result, there is very little available information in the literature, and almost none on a complete or comprehensive basis. Most mines have no historical or contemporary ground-water monitoring information.

2. EPA's limited field monitoring shows environmental transfer of mine waste constituents to ground water, but not necessarily transfer of the EP toxic constituents of concern. Mine waste constituents--both indicator sulfates, chlorides, and some elements that could be

considered environmentally harmful--were shown to migrate from waste management areas to local aquifers. Short-term monitoring detected seepage from tailings impoundments (a copper, lead, phosphate sand, and two gold impoundments), a copper leach dump, and a uranium mine water pond. However, the EP toxic constituents of concern did not appear to have migrated at these sites during the short period of this study.

3. <u>EPA's limited field monitoring generally did not show contamination of surface waters, but this may be the result of local circumstances of management, climate, and parameters monitored.</u> Surface water contamination would not be expected downstream from an intact tailings impoundment. However, abnormally heavy precipitation could lead to releases or bypasses to protect the integrity of the impoundment dam.

4. <u>Other scattered monitoring study data suggest mixed or inconclusive results regarding ground water and surface water contamination by constituents of concern.</u> In Arizona, copper mine runoff has degraded surface water, and uncontained leachate from copper leach dump operations has degraded ground water by lowering pH and increasing concentrations of sulfates, copper, and total dissolved solids. Abandoned gold recovery operations that did not treat wastes before release can be the source of persistent cyanide contamination. Generally, contaminant plumes from tailings impoundments (other than uranium mill tailings impoundments) have not been studied.

6.2.5 <u>Evidence of Damage</u>

The Agency's conclusions on observed damage to the environment and health are based on an extensive survey of State government natural resource and health agency files through 1984 to obtain evidence of environmental incidents, followed by review and evaluation of the evidence obtained. All 50 States were surveyed by telephone, and 10 were visited. The mining sites reported on were not visited to observe or verify data obtained in the survey. Several hundred initially reported incidents were evaluated and eventually narrowed down to 20 verifiable cases of damages having substantial documentation. The damage survey was supplemented by reviews of published reports and National Priorities List (Superfund) data.

1. Damage cases are about equally distributed between catastrophic (sudden releases, spills) and chronic (seepage, periodic runoff) incidents.
2. Documented damage typically involves physical or chemical degradation of surface water ecosystems, often including fish kills or reduction in biota, but seldom involves direct effects on human health.
3. A number of incidents of damage caused by mining wastes at currently active sites in the phosphate, gold, silver, copper, and uranium industries have been well documented in several States, including Arizona, Colorado, Florida, Missouri, Montana, and New Mexico. Similar results have been documented at inactive sites, but abandoned and Superfund sites may have additional problems.
4. Damage to surface waters has often been reducible or reversible by use of modified waste management practices or other physical controls.

6.2.6 Waste Management Practices

The Agency's conclusions on waste management practices are based on literature reviews, site visits in conjunction with waste sampling, engineering design studies, and consultation with State regulatory agencies and mine company engineers.

1. Site selection, including both the mine property itself and the specific location of waste storage, treatment, and disposal activities, is perhaps the single most important aspect of environmental protection in the mining industry. The selection of the mine property is based primarily on the ability of the operation to produce a commodity (e.g., copper, gold, etc.) at a competitive price and a reasonable profit. The cost of transporting waste via pipeline, conveyor, or truck to the disposal site is an important variable in determining the profitability of the mine, because of the large volume of material moved at most mines.
2. The potential for waste utilization as a solution, or even as a significant contributor, to waste management in most mining segments is extremely limited.
3. There are few major innovations under development that would lead to major changes in mine production processes or waste management practices.
4. The difference between "best practice" and typical practice is often significant among mines in many major segments. These differences are related to both voluntary management practices and variations in State regulations.
5. Within known technological options, there appear to be major opportunities for process modifications, some source separation of wastes, treatment of acids and cyanides, and, possibly, controlled release of certain effluents that could significantly reduce damage potentials in certain contexts.
6. Many waste management practices being applied to hazardous waste in

other industries--most notably caps and liners--have not been attempted for mining wastes.

6.2.7 Potential Costs of Regulation

The Agency conducted engineering cost analyses, using several different hypothetical regulatory scenarios, for a sample of 47 actual sites, and then extrapolated these costs to the universe of facilities in the copper, lead, zinc, silver, and gold mining segments. EPA's approach, methods, and assumptions are discussed briefly in Section 5 and in Appendix B.

1. For five metal mining segments, total annualized costs could be substantial, but vary considerably across different hypothetical regulatory scenarios. Annualized costs range from $7 million per year (for a scenario that emphasizes primarily basic maintenance and monitoring of RCRA hazardous wastes) to over $800 million per year (for a highly unlikely scenario that approximates a full Subtitle C regulatory approach emphasizing cap and liner containment for an expanded range of potentially hazardous wastes).
2. Almost 60 percent of total projected annualized costs at operating facilities can be attributed to the management of waste accumulated from past production.
3. Costs would vary greatly among segments. Some segments may not be affected at all (iron, molybdenum), because their waste streams apparently do not contain hazardous constituents. Total lifetime costs for affected segments could range from $45 million for zinc up to $8.3 billion for copper (for the highest cost scenario).
4. Costs would vary greatly among mines within segments. Incremental compliance costs, as a percentage of direct product cost, could vary as much as 25:1 among facilities within a given segment. Factors

affecting these differences include geography, ore grade, past waste accumulation, percentage of waste with hazardous characteristics, and process and waste management practice efficiencies.

6.3 RECOMMENDATIONS

Section 8002(f) of RCRA requires EPA to conduct a study of the adverse effects of mining waste and to provide "recommendations for Federal ...actions concerning such effects." Based on our findings from this study, we make several preliminary recommendations for those wastes and industry segments included in the scope of the study. The recommendations are subject to change based on continuing consultations with the Department of the Interior (DOI) and new information submitted through the public hearings and comments on this report. Pursuant to the process outlined in RCRA 3001(b)(3)(C), we will announce our specific regulatory determination within six months after submitting this report to Congress.

First, EPA is concerned with those wastes that have the hazardous characteristics of corrosivity or EP toxicity under current RCRA regulations. EPA intends to investigate those waste streams. During the course of this investigation EPA will assess more rigorously the need for and nature of regulatory controls. This will require further evaluation of the human health and environmental exposures mining wastes could present. EPA will assess the risks posed by various types of mining waste sites and alternative control options. The Agency will perform additional waste sampling and analysis, additional ground-water or surface water monitoring analysis, and additional analysis of the feasibility and cost-effectiveness of various control technologies.

If the Agency determines through the public comments, consultation with DOI and other interested parties, and its own analysis, that a regulatory strategy is necessary, a broad range of management control options consistent with protecting human health and the environment will be considered and evaluated. Moreover, in accordance with Section 3004(x), EPA will take into account the "special characteristics of such waste, the practical difficulties associated with implementation of such requirements, and site-specific characteristics...," and will comply with the requirements of Executive Orders 12291 and 12498 and the Regulatory Flexibility Act.

Second, EPA will continue gathering information on those waste streams that our study indicates may meet EPA's criteria for listing--dump leach waste, because of its high metal concentrations and low pH, and wastes containing cyanides. Although these waste streams are potential candidates for listing as hazardous wastes, we need to gather additional information similar to the information gathered for the rulemaking for corrosive and EP toxic wastes. When we have gathered sufficient information, we will announce our decision as to whether to initiate a formal rulemaking. If the Agency finds it necessary to list any of these wastes, we will also develop appropriate management standards in the same manner as those for corrosive and EP toxic wastes.

Finally, EPA will continue to study radioactive waste and waste with the potential to form sulfuric acid. The Agency is concerned that radioactive wastes and wastes with the potential for forming acid may pose a threat to human health and the environment, but we do not have enough information to be able to conclude that they do. We will continue to gather information to determine whether these wastes should be regulated. If EPA finds that it is necessary to regulate these wastes, the Agency will develop the appropriate measures of hazard and the appropriate waste management standards.